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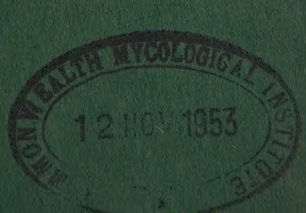

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STABILITY AND MINERAL COMPOSITION OF HEVEA LATEX

By

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In a group of mature seedling trees fertiliser treatments have been found to have a marked effect on latex stability. Associated with differences in stability are differences in the amounts of mineral constituents (P, K and Mg) present in the latex: low K and P and high Mg tending to be found in conjunction with low stability. It is emphasised that these observations have been made on material obtained from a single area, the soil of which is known not to be typical of Malayan rubber soils. Although the assessment of clonal latex characteristics is complicated by secondary influences it has been shown that some clones (notably Glenshiel 1) yield latex of abnormal stability wherever they are planted. There are theoretical and experimental grounds for the belief that phosphate-magnesium relationships are important in determining the natural stability of ammonia preserved latex.

It is well known that the properties of natural rubber latex vary from clone to clone, or from tree to tree in a mixed seedling stand; and are recognisably affected by the age of the trees and the system by which they are tapped. In this report it is shown that one important property of latex, its colloidal stability, depends on the mineral composition of the serum, and that this can in turn be affected by soil conditions.

PRELIMINARY SURVEY

To make a comprehensive estimate of the effects of soil conditions on latex properties it would be necessary at several seasons of the year to examine latex from a variety of clones growing in many different localities at different stages of maturity under different tapping systems. Such a survey would be extremely laborious and it was therefore decided to start with a more restricted survey.

In October 1948 samples of latex from eleven different clones were obtained from each of eleven estates scattered throughout Malaya. The latices were preserved immediately after collection with ammonia (1% NH_3) and sent in full, sealed bottles to the Rubber Research Institute, where they were concentrated by creaming with ammonium alginate, and tested about 30 days after collection. From the data so obtained, it was impossible to disentangle the secondary

effects of age and tapping system, but it was clear that major differences in latex solids content and in stability existed both between clones and between estates.

To confirm this observation, three of the estates were asked to submit further latex samples from the same clones in May 1949, *i.e.* seven months after the first sampling.

As variation in total solids content will not be further discussed in this report, it is sufficient to record that nearly all clones gave high t.s. (total solids) latex (>38%) at some estates and low t.s. (<30%) at others. There was no evidence that Tjir 1, as is sometimes alleged, is a clone that yields latex of abnormally low t.s.; for whereas 78 latices of 11 clones from 11 estates had total solids contents ranging from 25 per cent to 47 per cent in the October 1948 sampling, eight samples of Tjir 1 latex ranged in total solids content from 27 per cent to 46 per cent. Latices from the Rubber Research Institute Experiment Station, which has an exceptionally light sandy soil, all exhibited a much higher total solids content than latices collected elsewhere from the same clones of the same age under the same tapping system.

Mechanical stability was determined by stirring at high speed under conditions approximating to those recommended by the American Society for Testing Materials. The results of tests on latex from the three estates which were sampled twice at different seasons are summarised in TABLE I.

TABLE I: MECHANICAL STABILITY OF CREAM

Latices from three estates sampled (1) October 1948 and (2) May 1949. Values in minutes determined about 30 days after collection.

Clone	*Estate-1*		*Estate-9*		*Estate-10*	
	Oct 1948	*May 1949*	*Oct 1948*	*May 1949*	*Oct 1948*	*May 1949*
RRIM 500	—	8.9	2.9	8.4	3.6	—
RRIM 501	3.5	4.1	3.4	3.3	1.2	4.2
RRIM 506	4.2	8.1	3.5	8.3	1.9	4.1
RRIM 512	4.2	3.0	3.1	5.5	2.7	2.9
Tjir 1	5.3	3.4	4.3	6.2	1.9	3.2
Tjir 16	4.1	3.9	9.6	7.9	1.2	1.6
PB 86	4.0	13.1	2.3	6.8	2.5	2.7
PB 186	4.8	10.7	9.6	15.9	—	—
Pil B84	—	11.3	5.3	26.0	3.9	13.1
Gl 1	2.1	2.5	0.4	3.0	0.1	0.1
BD 5	5.1	16.2	2.1	30.0	2.0	0.1
Mean	4.2	7.7	4.2	11.0	2.1	3.6

From these results and from tests on the latices of other estates included in the first sampling survey, it was concluded that clone Gl 1 yields an exceptionally unstable latex wherever it is planted; that the other clones included in the survey do not exhibit consistently high or low latex

stability (though Pil B84 and PB 186 may perhaps be more stable than average); and that there are marked differences in the level of latex stability between estates.

INFLUENCE OF SOIL CONDITIONS

As differences between estates could conceivably be due to differences in soil conditions, arrangements were made to study the properties of latex from trees growing in areas which are known to differ with respect to certain soil factors. Suitable material for such a study was to be found in Field 6 of the Rubber Research Institute Experiment Station the plots of which had received different fertiliser treatments for many years.

This field trial is designed to compare the effects of six fertiliser treatments, *viz* no fertilisers (O), complete organic (Org), N, NP, PK, NPK. The six fertiliser treatments are set out in sixfold replication in a latin square design. The area was planted with seedling rubber in 1928, and fertiliser treatments were applied annually from 1928 to 1936, biennially from 1936 to 1940, and twice since 1947. In September 1949 and again in October, latex samples were taken from each of the 36 plots of Field 6. The samples were ammoniated immediately after collection, concentrated by creaming and tested for mechanical stability ten to twelve days after collection. The analysis of variance and the treatment means are recorded in TABLE II.

It is a defect of the experimental design used in Field 6 that the effects of the individual fertiliser ingredients and their interactions (if any) cannot be separated with confidence. Nevertheless, it seems clear that in this particular field fertiliser treatments have had a highly significant effect on latex stability. No effect due to nitrogen or organic manure can be detected, but phosphate and potash together increase stability. It seems probable that this effect is due mainly to potash but the design of the experiment is such that these two ingredients cannot be evaluated separately; we can only evaluate the effect of P when K is absent, and of K when P is present.

In a separate experiment latex samples were collected (July 1949) and tested for stability by the method of stirring at low speed in the presence of zinc oxide (L.A.C. test). The samples were tested after 10 to 15 days storage and again after 50 days. The analysis of variance and the treatment means are recorded in TABLE III.

The effects of fertiliser treatments on L.A.C. stability were similar to the effects on mechanical stability; the data of TABLE III however show in addition that the latex of plots receiving potash did not decrease in stability on storage, whereas latex from non-potash plots tended to become unstable.

To check the conclusion that fertilisers have a significant effect on the stability of latex from Field 6, and on the changes that occur during storage, two further collections were made in March 1950 from the 24 plots receiving

TABLE II: EFFECT OF FERTILISER TREATMENTS ON MECHANICAL STABILITY OF CREAMED LATEX FROM FIELD 6. R.R.I. EXPERIMENT STATION

Analysis of variance

Source	*d.f.*	*Mean squares*
Treatments	5	49.791 *ss*
Rows	5	6.652
Columns	5	13.182
Remainder (a)	20	7.938
Months	1	417.123 *sss*
Months × treatments	5	0.706
Remainder (b)	30	5.873

ss denotes $P < 0.01$
sss denotes $P < 0.001$

Treatment means

Treatment	*Mean mechanical stability (minutes)*	
Org	7.59	
O	9.07	8.57
N	8.07	
NP	9.06	
PK	12.52	12.21
NPK	11.90	
s.e. of a mean	± 0.81	± 0.58
Min. 5% sig. dif.	2.50	—
Min. 1% sig. dif.	3.27	2.31

Monthly means

Month of collection	*Mean mechanical stability*
September 1949	12.11 *minutes*
October 1949	7.29 *minutes*
s.e. of a mean	± 0.40

TABLE III: EFFECT OF FERTILISER TREATMENTS ON ZINC OXIDE STIRRING STABILITY (L.A.C. STABILITY) OF AMMONIA PRESERVED LATEX FROM FIELD 6, R.R.I. EXPERIMENT STATION

Analysis of variance

Source	*d.f.*	*Mean squares*
Treatments	5	223.228 *ss*
Rows	5	48.914
Columns	5	14.036
Remainder (a)	20	38.554
Storage period	1	218.405 *ss*
Storage × treatments	5	59.613 *ss*
Remainder (b)	30	15.776

Treatment means: L.A.C. stability (thous revs)

Treatment	*10-15 days storage*	*50 days storage*	*difference*	
Org	26.15	21.90	− 4.25	
O	28.42	21.52	− 6.90	− 8.10
N	29.48	20.18	− 9.30	
NP	28.80	25.02	− 3.78	
PK	32.13	33.40	+ 1.27	+ 1.66
NPK	32.82	34.87	+ 2.05	
s.e. of a treatment mean	± 1.62	± 1.62	± 2.29	± 1.62
Min. 5% sig. dif.	4.68	4.68	6.64	4.68
Min. 1% sig. dif.	6.31	6.31	8.93	6.31

treatments O, N, PK, and NPK. The latices were bulked by treatments, concentrated by creaming with ammonium alginate, and tested for mechanical stability after ten days and after *ca* four to five months (TABLE IV). Other characteristics of the creamed latices are tabulated in TABLE V.

If we ignore the abnormally high Volatile Acid No., KOH No. and conductivity exhibited by the stored N latex collected on 22 March 50 (on the supposition that these characteristics were the result of accidental contamination) the test results in TABLE V reveal no marked differences in the concentration of titratable acids due to fertiliser treatments. The results in TABLE IV, however, provide strong confirmation that latex from trees receiving PK and NPK fertilisers is more stable, particularly after a period of storage, than latex from trees not manured with PK.

TABLE IV: MECHANICAL STABILITY (SECONDS) OF CREAMED LATEX

Collected March 1950 from Field 6

Fertiliser treatment	*Collected 2 March*			*Collected 22 March*		
	Aged 10 days	*Aged 157 days*	*Increment on storage*	*Aged 10 days*	*Aged 129 days*	*Increment on storage*
O	367	631	264	370	475	105
N	346	534	188	343	265	− 78
PK	425	777	352	395	902	507
NPK	477	868	391	410	898	488

It must be emphasised that Field 6 is an exceptionally potash deficient area and is not at all typical of Malayan rubber soils. The effect of potash on latex stability observed in this experiment may not therefore be reproducible on other soils.

Having shown that fertiliser treatments in Field 6 have a significant effect on latex stability we proceeded to examine the possibility that the effect is correlated with a differential uptake of soil nutrients into the latex system. Latex collected on two days in 1949 (27 July and 13 September) from each of the 36 plots of Field 6 was well mixed in the field and 50 ml samples were withdrawn and evaporated to dryness at 70°C. The dried latex films were later analysed for nitrogen, phosphorus, potassium and magnesium by methods currently used in these laboratories. In order to limit the number of analytical determinations a plan of partial replication was adopted. The six rows of the latin square were divided into pairs at random and the samples from these rows were treated as follows:

Rows 6 and 4 A single analysis is made for each plot and day (24 determinations).

Rows 1 and 3 A blend of the two day samples from each plot is made and duplicate analyses are made on each blend (24 determinations).

Rows 2 and 5 A blend of the two day samples from each plot is made and a single analysis is made on each blend (12 determinations).

The analytical determinations were done in random order. The analysis in duplicate of each plot/day sample would have required 144 determinations for each constituent, whereas the abbreviated scheme required only 60 determinations and yet provided sufficient data to assess the significance of differences due to treatments.

TABLE V: CHARACTERISTICS OF CREAMED LATEX

Collected March 1950 from Field 6

Treatment	Collected 2 March						Collected 22 March					
	On 10th day	On 157th day					On 10th day	On 129th day				
	NH_3%	NH_3%	pH	VA No.	KOH No.	Cond.	NH_3%	NH_3%	pH	VA No.	KOH No.	Cond.
O	0.53	0.52	10.10	11.9	0.88	4.81	0.53	0.47	10.20	18.5	0.89	4.78
N	0.57	0.53	10.33	5.4	0.86	4.40	0.54	0.47	10.13	30.7	1.04	5.28
PK	0.57	0.55	10.40	9.5	0.79	4.39	0.52	0.47	10.32	11.4	0.73	4.13
NPK	0.53	0.53	10.10	9.2	0.80	4.35	0.53	0.48	10.30	7.3	0.75	4.30

VA No. = *Volatile acids (meq per 1000 gm latex)*

Cond. = *Specific conductivity (millimho)*

TABLE VI: EFFECT OF FERTILISER TREATMENTS ON COMPOSITION OF LATEX FROM PLOTS OF FIELD 6, R.R.I. EXPERIMENT STATION

Analysis of variance

Source		d.f.	Mean squares (parts per 100,000 parts latex solids) N	P	K	Mg
A						
Between treatments		5	202.8	287.3 *s*	2193.9	206.6 *ss*
Between rows	*Plots within treatments*	5	436.1	65.1	2311.8	80.7
Between columns		5	512.8	98.5	396.9	34.9
Residual		20	504.0	106.1	991.3	44.1
B						
Between days		1	7350.0	30.4	1650.0	40.0
Days × treatments		5	803	35.3	1087.9	122.5 *ss*
Days × plots of the same treatment		6	1500 *sss*	310.1 *sss*	532.5 *s*	39.2
Between tests within blends		12	167	32.8	176.3	17.8

Section *A* of the analysis of variance (TABLE VI) is based on means per plot as units whereas section *B* is based on individual observations. Formally the analysis of section *A* may be criticised in that treatment or plot means are derived from unequal numbers of analytical determinations. However, the 'between determinations' variance is relatively small and no appreciable error is introduced by performing a straightforward latin square analysis using means per plot as unit throughout. It will be observed in section *B* that information on the 'between days' effect and on interactions with days is derived solely from data supplied by the plots in rows 4 and 6, whilst rows 1 and 3 provide the data used for estimating the error variance of the analytical determination.

From the analysis of variance it is evident that there are no significant 'between rows' or 'between columns' effects except in the case of potassium content where the 'between rows' effect is more pronounced than the possible treatment effect which has a significance level of about 10 per cent.

Significant treatment effects are observed for P and Mg content of latex but not for N content. The situation with K is less definite; the 'treatments' effect corresponds to a 10 per cent level of significance and is perhaps too large to be dismissed with confidence.

Considering section *B* of the analysis of variance we can generally detect no day effects but there is some evidence that the magnesium content is affected by fertiliser treatments in a manner that varies from day to day.

TABLE VII: COMPOSITION OF LATEX FROM PLOTS OF R.R.I. EXPERIMENT STATION FIELD 6 FERTILISER TRIAL

Latex Constituent	*Treatment means, parts per 100,000 parts latex solids*							
	O	*Org*	*N*	*NP*	*PK*	*NPK*	*S.e. of a mean*	*5% sig. dif. between two means*
Nitrogen	492	484	482	482	477	491	± 9	27
Phosphorus	97	106	100	101	115	112	± 4	12
Potassium	418	406	397	394	446	422	± 13	38
Magnesium	70	73	68	66	58	59	± 3	8

From the table of treatment means (TABLE VII) we see that the PK and NPK treatments give a latex containing significantly more phosphorus and significantly less magnesium than the other treatments. For potassium content, as has been mentioned, the treatment differences do not reach the 5 per cent level of significance but there is an indication that the PK treatment mean is high.

The main effects of fertiliser treatments on stability and latex composition are more clearly demonstrated if we consider only the treatment means for the plots receiving inorganic PK fertiliser and for those not receiving PK (TABLE VIII).

TABLE VIII: EFFECT OF PK MANURING ON LATEX STABILITY AND COMPOSITION FIELD 6

Treatment	*Latex composition, parts per 100,000 parts latex solids*			*Mechanical stability (minutes)*
	Phosphorus	*Potassium*	*Magnesium*	
O	97	418	70	9.07
N	100	397	68	8.07
PK	115	446	58	12.52
NPK	112	422	59	11.90
PK absent	98.5	407.5	69	8.57
PK present	113.5	434	58.5	12.21
Difference	+ 15.0 ± 4.2	+ 26.5 ± 12.9	− 10.5 ± 2.7	+ 3.64 ± 0.81
Level of significance of PK effect	< 1%	Almost 5%	< 1%	< 0.1%

It is of interest to examine the correlation coefficients relating the various latex constituents and the mechanical stability, *S*. Three kinds of correlation coefficient are shown in TABLE IX; the 'total' correlation coefficients are those obtained by correlating the variables over the 36 plots, the 'treatment' coefficients arise from correlating over the six fertiliser treatment means, and the 'residual' correlation coefficients relate the residual terms in the analysis of variance of TABLE VI *A*. All these coefficients are readily

obtained by analysis of covariance on the same lines as the analysis of variance of TABLE VI A. Other correlation coefficients corresponding to row means and column means could be calculated similarly but are not of general interest.

TABLE IX: CORRELATION COEFFICIENTS

Variables	*'Residual' coeff (19 d.f.)*	*'Treatment' coeff (4 d.f.)*	*'Total' coeff (34 d.f.)*
NP	+ 0.17	− 0.32	+ 0.12
NK	+ 0.50 *s*	− 0.12	+ 0.35 *s*
NMg	− 0.37	+ 0.20	− 0.15
PK	+ 0.39	+ 0.74	+ 0.45 *ss*
PMg	− 0.12	− 0.77	− 0.32
KMg	− 0.46 *s*	− 0.67	− 0.60 *sss*
SN	− 0.04	− 0.10	− 0.15
SP	− 0.03	+ 0.80 †	+ 0.35 *s*
SK	+ 0.11	+ 0.82 *s*	+ 0.26
SMg	− 0.34	− 0.97 *ss*	− 0.47 *ss*
S(P/Mg)	+ 0.21	+ 0.95 *s*	+ 0.50 *ss*

† *almost significant*

Examination of the correlation coefficients calculated from fertiliser treatment means indicates that latices with relatively high phosphorus or potassium content appear to have high mechanical stability, whereas latices with relatively high magnesium content have low mechanical stability. As one would expect, therefore, the phosphorus/magnesium ratio is also positively correlated with mechanical stability. A complete interpretation of the data involving partial correlation has not been attempted, but certain partial correlation coefficients shown in the lower part of TABLE X throw further light on the association of stability and the latex composition.

TABLE X: CORRELATION COEFFICIENTS

(calculated using treatment means)

Correlation Coefficients from Table IX

SP	:	+ 0.80 †
SK	:	+ 0.82 *s*
SMg	:	− 0.97 *ss*

Partial Correlation Coefficients

SP.K	:	+ 0.50
SP.Mg	:	+ 0.34
SK.P	:	+ 0.57
SK.Mg	:	+ 0.94 *s*
SMg.P	:	− 0.92 *s*
SMg.K	:	− 0.99 *ss*
SP.KMg	:	− 0.38
SK.PMg	:	+ 0.94 *s*
SMg.PK	:	− 0.99 *ss*

† *almost significant*

It is noteworthy that the correlation between mechanical stability and phosphorus content is no longer significant when the potassium and magnesium content is constant, (*i.e.* SP.KMg = – 0.38) ; the implication is that the apparent relation between stability and phosphorus (*i.e.* SP = + 0.80) arises because of association between phosphorus content and potassium and magnesium content. The significant negative correlation between mechanical stability and magnesium content persists even when estimated under conditions of fixed phosphorus or potassium content, (SMg.PK = – 0.99). Similarly, we establish that the significant positive correlation between stability and potassium content has not arisen merely because of association between potassium, phosphorus and magnesium contents.

Significant correlation coefficients involving mechanical stability are not established among the 'residual' correlation coefficients of TABLE IX; that is, for a given fertiliser treatment and making allowance for row and column effects in Field 6, there is no reliable evidence of association between stability and composition of latex. This is not surprising since major changes in mechanical stability resulted from fertiliser differences. Two 'residual' correlation coefficients, NK and KMg, attain significance and arise independently of fertiliser treatment (or row or column influence) ; however, calculating partial coefficients we obtain,

$$NK.Mg = + 0.40$$
$$KMg.N = - 0.34$$

The present evidence is therefore insufficient to attribute any real relationship between nitrogen and potassium content or between magnesium and potassium content.

To summarise the main positive results of this study of latex from Field 6, we can say that manuring with PK fertiliser appears to have reduced the magnesium content, and raised the phosphorus and, probably, the potassium content of the latex, and at the same time to have increased the mechanical stability. As a result of this fertiliser effect we are able to detect marked negative correlation between mechanical stability and magnesium content and marked positive correlation between mechanical stability and potassium content. An apparent relation between stability and phosphorus is shown to have arisen merely because of association between phosphorus and the magnesium and potassium contents.

CHARACTERISTICS OF CLONAL LATICES

From what was written at the outset, it will be apparent that purely clonal characteristics are generally difficult to assess because of the superposition of local effects and of effects due to the age of the trees and the system of tapping employed. Nevertheless it is well established that latex of clone Gl 1 is invariably unstable, and that clones Pil B84 and

PB 186, among the few that have been studied, generally produce latex of higher than average stability.

Because Gl 1 is one of the highest yielding Malayan clones the characteristics of its latex have been the subject of much investigation and discussion. The instability of Gl 1 latex has been ascribed by PATON[1] to an abnormally low content of alcohol soluble phosphorus (phospholipin), and by MADGE, COLLIER and PEEL[2] to an abnormally high magnesium content. These views receive considerable support from a mass of disconnected data available in this laboratory, which show that the ratio of total phosphorus to magnesium in Gl 1 latex is consistently lower than average. Indeed, the low phosphorus/magnesium ratio of this notoriously unstable latex, coupled with the positive correlation of stability with P/Mg ratio reported earlier in this paper for a particular set of seedling latices, prompts the generalisation that the ratio of phosphorus to magnesium content is a determining factor for stability in all latices.

A closer study of the stability and composition of latices from various sources shows, however, that instability is not invariably associated with low phosphorus/magnesium ratio; indeed, instances can be cited of unstable latices having exceptionally high phosphorus/magnesium ratios. The following examples are illustrative:

i Four clones at the Rubber Research Institute Experiment Station, Field 18 (budded 1932)—two stable (PB 186, Tjir 1) and two unstable (Gl 1, AVROS 152) showed little inter-clonal variation in phosphorus content; however, it was apparent that one clone, Gl 1, had a smaller phosphorus content than the other three, PB 186, Tjir 16, AVROS 152, which were in close agreement. Differences in magnesium content on the other hand were very pronounced, with clone Gl 1 having the highest content (TABLE XI). Estimates of mean phosphorus/magnesium ratio for the four clones ranged from 0.68 (Gl 1) to 2.72 (AVROS 152), and the latices with the highest and lowest phosphorus/magnesium ratios were the least stable (TABLE XII).

TABLE XI: MINERAL CONTENT OF CLONAL LATICES FROM TWENTY-YEAR OLD BUDDINGS IN FIELD 18, R.R.I. EXPERIMENT STATION

Clone means

(parts per 100,000 parts latex solids)

Clone	*P*	*K*	*Mg*	*P/Mg*
PB 186	164	608	84	1.95
Gl 1	114	609	167	0.68
Tjir 16	177	862	130	1.36
AVROS 152	182	689	67	2.72
S.e. of a clone mean	21	52	9	
5% sig. dif. between two clone means	61	155	27	

TABLE XII: STABILITY AND P/MG RATIO FOR CLONES OF TABLE XI

Clone	*Mean P/Mg*	*Mechanical stability (sec)*			
		Day 1	*Day 2*	*Day 3*	*Av.*
Gl 1	0.68	120	121	114	118
Tjir 16	1.36	463	476	439	466
PB 186	1.95	644	638	515	566
AVROS 152	2.72	144	115	116	125

ii In another experiment comparison was made between the 'unstable' clone RRIM 501 and the 'stable' clone Pil B84, each growing on two contrasted types of soil: a light sandy soil at the R.R.I. Experiment Station and a peaty clay soil at Bukit Rajah Estate. On the clay soil Pil B84 was found to have a lower phosphorus content than RRIM 501, and on both soils a higher magnesium content (TABLE XIII).

TABLE XIII: PHOSPHORUS AND MAGNESIUM CONTENT OF LATEX FROM CLONES RRIM 501 AND PIL B84

(parts per 100,000 parts latex solids)

Estate	*Phosphorus*			*Magnesium*		
	RRIM 501	*Pil B84*	*AVROS*	*RRIM 501*	*Pil B84*	*AVROS*
R.R.I.E.S.	136	146	141	78	106	92
Bukit Rajah	200	163	182	78	124	101
Clone means	168	155	—	78	115	—
S.e. of any estate/clone mean	± 9			± 4		
5% sig. dif. between two such means	28			12		

The mean phosphorus/magnesium ratio for Pil B84 latex was 1.35 and for RRIM 501 latex 2.15. For potassium content there was no evidence of clonal differences at either estate or of estate differences for either clone.

From these two examples it is clear that the defective latex stability of clones AVROS 152 and RRIM 501, unlike that of clone Gl 1, cannot be ascribed to high magnesium content or low phosphorus/magnesium ratio. Either there is an optimum value for the phosphorus/magnesium ratio below and above which stability is adversely affected, or other factors are present which condition the stability.

In an attempt to elucidate further the stability/composition relationships of the latices examined in *ii* above, correlation coefficients were calculated for each clone at each estate. These coefficients together with the derived partial correlation coefficients are summarised in TABLE XIV.

TABLE XIV: CORRELATION COEFFICIENTS RELATING MECHANICAL STABILITY WITH PHOSPHORUS, POTASSIUM AND MAGNESIUM CONTENT

Estate	*Clone*	*Correlation coefficients (8 degrees of freedom)*			
		SP	*SK*	*SMg*	*S × P/Mg*
R.R.I.E.S.	*RRIM 501*	0.00	− 0.20	+ 0.66 *s*	− 0.53
„	*Pil B84*	+ 0.71 *s*	− 0.16	+ 0.17	+ 0.40
Bukit Rajah	*RRIM 501*	− 0.44	− 0.19	− 0.56	− 0.28
„	*Pil B84*	+ 0.92 *sss*	+ 0.67 *s*	− 0.33	+ 0.92 *sss*
		Partial correlation coefficients			
		SP.KMg	*SK.PMg*	*SMg.PK*	*S × P/Mg.K*
R.R.I.E.S.	*RRIM 501*	+ 0.39	+ 0.55	+ 0.81 *s*	− 0.55
„	*Pil B84*	+ 0.80 *s*	− 0.43	− 0.43	+ 0.39
Bukit Rajah	*RRIM 501*	− 0.40	+ 0.43	− 0.36	− 0.23
„	*Pil B84*	+ 0.88 *ss*	− 0.37	− 0.47	+ 0.86 *ss*

Some of the correlation coefficients remain essentially unchanged by conversion to partial coefficients, but others undergo a marked change in value, and it is evident that the correlation of mechanical stability with, say, potassium can only be adequately studied if due account is taken of the effect of other factors, phosphorus and magnesium.

The respective partial coefficients for clone Pil B84 at R.R.I. Experiment Station correspond closely with those of the same clone at Bukit Rajah Estate; in particular the stability is positively correlated with phosphorus content at both estates. There is some indication, too, of a negative correlation with the same clone between stability and potassium and between stability and magnesium, although significance is not established.

Considering now clone RRIM 501, we find a much more confusing picture. The respective coefficients obtained with the R.R.I. Experiment Station data do not agree with the corresponding Bukit Rajah coefficients, nor with the coefficients obtained for Pil B84 at either estate. The reason becomes apparent when we examine the total regressions and find that not only is the level of stability but also its variability much smaller with clone RRIM 501 than with clone Pil B84. This suggests the presence of other factors conditioning the stability value, and it may be that if these

could be identified and allowed for greater consistency would persist in the stability, phosphorus, potassium and magnesium relationships.

It is possible that the absence of significant correlation between stability and phosphorus content for clone RRIM 501 is due to the relatively high ratio of mean phosphorus to mean magnesium content of its latex; for if we assume that the role of phosphorus (or rather of serum phosphate) is to suppress the destabilising action of magnesium, by precipitating or complexing magnesium ions, a small amount of phosphate in excess of that required to react with the magnesium will not greatly affect the net stability of the latex. Only where phosphorus is deficient, or where phosphorus and magnesium are fairly evenly balanced, will variation in phosphorus content be accompanied by variation in phosphorus content be accompanied by variation in stability.

In latex of clone RRIM 501, with a mean phosphorus to mean magnesium ratio of 2.15, the phosphorus is probably already in considerable excess of magnesium, whereas in latex of clone Pil B84, with a ratio of 1.35, the two constituents may be more evenly balanced and small variations in phosphorus content may be expected to have a marked influence on stability. Thus for clone Pil B84, but not for RRIM 501, we may expect to find a positive correlation between stability and phosphorus content—as indeed we do. (TABLE XIV).

TABLE XV: LATEX FROM SIX CLONAL AREAS CLASSIFIED ACCORDING TO STABILITY AND P/MG RATIO

P/Mg	*Low stability*	*Average or high stability*
< 1.0	*Gl 1*	—
1.0-2.0	—	*Tjir 16, PB 186, Pil B84*
> 2.0	*RRIM 501, AVROS 152*	—

Association of low stability with high as well as with low phosphorus/magnesium ratio seems to be similarly explicable in terms of an interaction between phosphate and magnesium ions. When the amount of phosphate is insufficient to remove all the magnesium ions (as in Gl 1 latex) stability will be impaired by surplus divalent cations remaining in solution. On the other hand, a considerable excess of phosphate will destabilise the latex as a result of mutual interaction of phosphate anions in solution with charges on the surface of the latex particles. If the phosphorus and magnesium were wholly present in ionic form in the serum the weight ratio required for complete precipitation of both constituents as NH_4MgPO_4 would be 1.35. Thus latices with phosphorus/magnesium ratio either less than or greatly in

excess of some optimum value would tend to be unstable. Such a hypothesis would account plausibly for the observation that of the six clonal latices studied in this investigation, the three showing abnormally low stability have phosphorus/magnesium ratio either less than 1.0 or greater than 2.0 (TABLE XV), while the three with normal or high stability have phosphorus/magnesium ratios within the limits 1.0 and 2.0.

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